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SIMULATING DEFECTS, WHICH WERE RESULT OF INCORRECT DOSAGE OF CHEMICAL FOAMING AGENT IN THE PROCESS OF LOW-PRESSURE POLYMER MOULDING, USING MAGMA

Mag. Stanislav Gatsev

Senior Assistant Professor Dr. Eng Yasen Hadjitodorov.

ABSTRACT

In the article, we described the process and the data needed to create a material in Magma Soft database. We showed how we defined the process low-pressure polymer moulding in Magma Soft. With this definition we executed simulations. The goal was to find a parameters, which can help us simulate defects, result of incorrect dosage of chemical foaming agent in the molten material. We ended up having good results by redefining one of the material's parameters. We also executed a real moulding processes, which we used for validating the results.

KEYWORDS: Simulation, Molding, Polymer, Chemical foaming agent, Magma

INTRODUCTION:

Magma Soft has numerous different configurations of the casting process, which may be modified. The system provides the possibility to set parameters of the material, which will be used for casting, material of the cast and the casting system. In the meantime the whole process and every parameter of it can be modified and configured. [5] These capabilities are a very good base for simulating processes, which were not initially supported by the Magma Soft system. Such process is the low-pressure polymer moulding with chemical foaming agent. In the following article we will go through the possibilities to use in practice Magma Soft like simulation tool for the process of low pressure polymer moulding with chemical foaming agent. In detail, we will simulate defects, which are result of incorrect dosage of chemical foaming agent in the molten polymer. This is one of the most important characteristics of this process, as deviations in the dosage result in a huge quality defects on the part. The selection correct amount of chemical foam agent is a process of long calibration. This calibration is usually done on already manufactured mould and by execution of real experiments, which takes time and costs a lot of money. [2] Development of a system, which can simulate this process and give better understanding of the way the incorrect dosage of chemical foaming agent may result in defects on the final part, will lower the time and the resources needed for moulds manufacturing.

MATERIALS AND METHOD:

The main goal of the research is to define the parameters, which may allow simulation of defects, result of incorrect dosage of the chemical foaming agent in the process of low pressure polymer moulding. We will demonstrate how Magma can handle such process and its ability to predict defects, result of incorrect process execution. By this we will also develop a module, which can be used for future simulations of the process. This module will be used for defining the correct dosage of chemical foaming agent in the molten polymer also for future parts and moulds. [1] Changes in the percentage of chemical foaming agent leads to significant changes in the parts molded from HDPE.

Our first step will be to create a material in the Magma's database, which describes the chemical and physical characteristics of the polymer, which will be used for the following experiments. We will execute simulations, which will help us define the parameters, influencing the process and may cause defects close to the ones we expect from incorrect execution of the moulding process. As last stage we will compare and validate the results from the simulation with real experiments of moulding the parts.

We started with the first step - the creation of polymer material in Magma Soft database. A material, which will have the chemical and physical characteristics of the one, we will use in the our following experiments. This is required as Magma has default libraries only with metal alloys. The polymer, which we will use is HDPE (High-density polyethylene). We took the material's characteristics from its technical datasheet [4] and from the standard parameters, which were defined in the database of MoldFlow [3], a software product for polymer moulding simulations. MoldFlow is the product were using for comparing the results we had in the earlier stages of our experiments. After gathering all needed parameters we converted them in the measuring units needed by Magma Soft.

The first group of parameters, which we needed to define, were the so called general and also one, which are not changing as function of temperature. They are show in Table 1.

Table 1

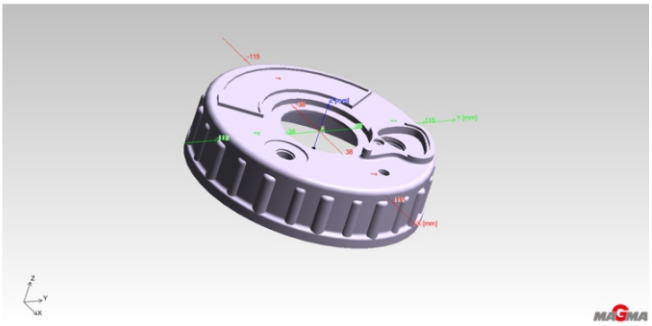
Solidus temperature	180° C
Liquidus temperature	240° C
Initial temperature of the molten material	280° C
Specific energy	171.54 kJ/kg

The parameters, which are temperature dependent are defined as function of the temperature against the values of the parameter. We have taken in account the specifics of the mathematical module of Magma Soft and set values for 1° C and 2000° C, even though such values make no sense in the context of polymer moulding process. These definitions are shown in Table 2.

Table 2

Thermal Conductivity	1° C	0.21110 W/mK
	2000 ° C	0.21110 W/mK
Specific Heat Capacity	1° C	2859 J/kgK
	2000 ° C	2859 J/kgK
Viscosity	1° C	1183.00 m^2/s
	180° C	1183.00 m^2/s
	200° C	968.9710 m^2/s
	220° C	809.3290 m^2/s
	240° C	687.4990 m^2/s
	2000 ° C	687.4990 m^2/s
Density	1° C	2151.6699 kg/m^3
	180° C	2151.6699 kg/m^3
	240° C	743.81 kg/m^3
	280° C	743.81 kg/m^3
	2000 ° C	743.81 kg/m^3

After having the material defined we got to the next step - setup the simulations with Magma Soft. We used the module for simulation of casting with low pressure. We creating moulding system, close as possible to the real one, which will be used for the following real experiments. This includes the moulding system and the cooling channel. Schema of it can be seen on Picture 1.



Pic. 1

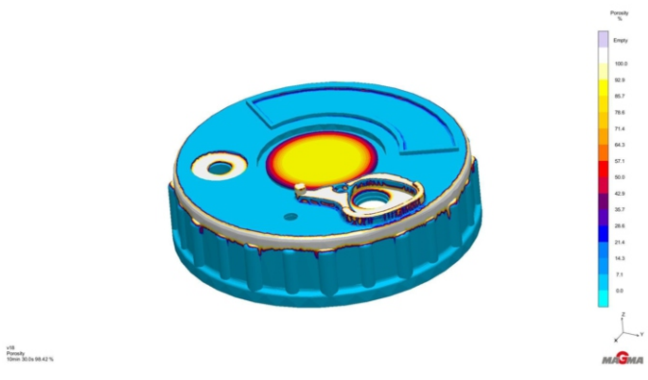
The insufficient amount of chemical foaming agent usually results in defects like incomplete filling of the mould (short shot) or sink marks. In order to simulate such behavior, we executed a series of simulations. The goal of these simulations was to define the parameters in the process or/and of the material, which change may result in such defects. Results from these simulations indicated that, when we changed the density of the material in the temperate region between liquidus and solidus temperatures, we may observe the expected behavior. So we started using this parameter as shrinkage coefficient.

The goal of changing the parameter was to simulate behavior of the molten material closest as possible to the one in the real process of low pressure polymer moulding with chemical foaming agent. In this process we have increase of the volume, which is result of the chemical reaction of the foaming agent. The increase of volume is dependent on the amount of agent in the molten material. With the simulations we observed a behavior that by lowering the mass for cubic meter, we were able to simulate process of increasing the volume of the molten material. This increase was happening only in the region between liquidus and solidus. This is expected behavior by the mathematical module of Magma Soft as it is developed for metal casting simulations. Having this results, we decided to start experimenting with this parameter by following the increase logic.

After we executed these simulation we ended up with values of this parameter, which we expected from such process. We set the density in a way, that after the molten material gets into the mould, its density decreases its volume 3 time (from 743.81 kg/m^3 to 300 kg/m^3). After that we define the standard for polymer moulding process of shrinkage by increasing the density. As a result from these modifications, we clearly observe the zones of short shot and sink marks on the final part. This density configuration is shown on Table 3. The results from the simulation on Picture 2.

Table 3

Density	1° C	450.00 kg/m^3
	180° C	450.00 kg/m^3
	210° C	320.00 kg/m^3
	240° C	300.00 kg/m^3
	270° C	500.00 kg/m^3
	280° C	743.81 kg/m^3
	2000 ° C	743.81 kg/m^3



Pic. 2

RESULTS AND DISCUSSION:

The final step was to execute real experiments with the mould, which was used for the simulations. The goal was to observe the actual defects, which are result of incorrect dosage of chemical foaming agent in the molten material. As final step to compare and validate this results against the ones from the already done simulations.

On Picture 3 we see a form moulded from these experiments. The amount of chemical foaming agent is ⅓ lower than the one, which is needed for correct process execution and no defects on the part.

We can clearly see the same defects on the upper side of the part and on upper edge. These defects are the same as the ones we observed on the simulations, with the same deviations in the volume.

Pic. 3

CONCLUSION:

It is possible to simulate defects result of incorrect dosage of chemical foaming agent in the molten material, by defining redefining the density of a material in Magma Soft. This simulations can be used as part of the calibration process, as it can simulate the defects and give clues to the mould designer about the correct dosage of foaming agent.

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